

MAXIM

1MHz, 20 μ A, Rail-to-Rail I/O Op Amps with Shutdown

MAX9914-MAX9917

General Description

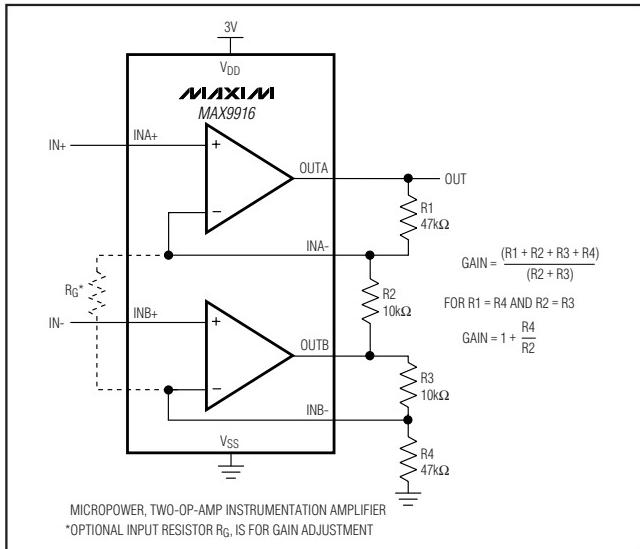
The single MAX9914/MAX9915 and dual MAX9916/MAX9917 operational amplifiers feature maximized ratio of gain bandwidth to supply current and are ideal for battery-powered applications such as portable instrumentation, portable medical equipment, and wireless handsets. These CMOS op amps feature an ultra-low 1pA input bias current, rail-to-rail inputs and outputs, low 20 μ A supply current, and operate from a single 1.8V to 5.5V supply. For additional power conservation, the MAX9915/MAX9917 feature a low-power shutdown mode that reduces supply current to 1nA, and puts the amplifier outputs in a high-impedance state. These devices are unity-gain stable with a 1MHz gain-bandwidth product.

The MAX9914 and MAX9915 are available in 5-pin and 6-pin SC70 packages, respectively. The MAX9916 is available in an 8-pin SOT23 package, and the MAX9917 in a 10-pin μ MAX® package. All devices are specified over the -40°C to +85°C extended operating temperature range.

Applications

- Portable Medical Devices
- Portable Test Equipment
- RF Tags
- Laptops
- Data-Acquisition Equipment

Typical Operating Circuit



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Features

- ◆ High 1MHz GBW
- ◆ Ultra-Low 20 μ A Supply Current
- ◆ Single 1.8V to 5.5V Supply Voltage Range
- ◆ Ultra-Low 1pA Input Bias Current
- ◆ Rail-to-Rail Input and Output Voltage Ranges
- ◆ Low $\pm 200\mu$ V Input Offset Voltage
- ◆ Low 0.001 μ A Shutdown Current
- ◆ High-Impedance Output During Shutdown (MAX9915/MAX9917)
- ◆ Unity-Gain Stable
- ◆ Available in Tiny SC70, SOT23, and μ MAX Packages

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX9914EXK-T	-40°C to +85°C	5 SC70-5	AGB
MAX9914EXK-T	-40°C to +85°C	5 SC70-5	AGB
MAX9915EXT-T	-40°C to +85°C	6 SC70-6	ACB
MAX9915EXT-T	-40°C to +85°C	6 SC70-6	ACB
MAX9916EKA-T	-40°C to +85°C	8 SOT23-8	AEJZ
MAX9916EKA-T	-40°C to +85°C	8 SOT23-8	AEJZ
MAX9917EUB	-40°C to +85°C	10 μ MAX	—
MAX9917EUB+	-40°C to +85°C	10 μ MAX	—

+Denotes lead-free package.

Selector Guide

PART	AMPLIFIERS PER PACKAGE	SHUTDOWN MODE	PACKAGE
MAX9914EXK-T	1	No	5 SC70-5
MAX9915EXT-T	1	Yes	6 SC70-6
MAX9916EKA-T	2	No	8 SOT23-8
MAX9917EUB	2	Yes	10 μ MAX

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For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

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ABSOLUTE MAXIMUM RATINGS

Power-Supply Voltage (V_{DD} to V_{SS}) -0.3V to +6.0V
 IN_+ , IN_- , OUT_- , \overline{SHDN}_- ($V_{SS} - 0.3V$) to ($V_{DD} + 0.3V$)
 Current into IN_+ , IN_- $\pm 20mA$
 Output Short-Circuit Duration to V_{DD} or V_{SS} Continuous
 Continuous Power Dissipation ($T_A = +70^\circ C$)
 5-Pin SC70 (derate 3.1mW/ $^\circ C$ above $+70^\circ C$) 247mW
 6-Pin SC70 (derate 3.1mW/ $^\circ C$ above $+70^\circ C$) 245mW

8-Pin SOT23 (derate 9.1mW/ $^\circ C$ above $+70^\circ C$) 727mW
 10-Pin µMAX (derate 5.6mW/ $^\circ C$ above $+70^\circ C$) 444mW
 Operating Temperature Range $-40^\circ C$ to $+85^\circ C$
 Junction Temperature $+150^\circ C$
 Storage Temperature Range $-65^\circ C$ to $+150^\circ C$
 Lead Temperature (soldering, 10s) $+300^\circ C$

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

($V_{DD} = 1.8V$ to $5.5V$, $V_{SS} = 0V$, $V_{CM} = 0V$, $V_{OUT} = V_{DD} / 2$, $R_L = \infty$ connected to $V_{DD} / 2$, $\overline{SHDN}_- = V_{DD}$, $T_A = +25^\circ C$, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{DD}	Guaranteed by PSRR test		1.8		5.5	V
Supply Current	I_{DD}	MAX9914/MAX9915	$V_{DD} = 1.8V$		20		μA
			$V_{DD} = 5.5V$	20	25		
		MAX9916/MAX9917	$V_{DD} = 1.8V$		40		
			$V_{DD} = 5.5V$	40	50		
Shutdown Supply Current	$I_{DD(\overline{SHDN}_-)}$	$\overline{SHDN}_- = GND$, MAX9915/MAX9917		0.001	0.5		μA
Input Offset Voltage	V_{OS}			± 0.2	± 1		mV
Input-Offset-Voltage Matching		MAX9916/MAX9917			± 250		μV
Input Bias Current	I_B	(Note 2)		± 1	± 10		pA
Input Offset Current	I_{OS}	(Note 2)		± 1	± 10		pA
Input Resistance	R_{IN}	Common mode			1		$G\Omega$
		Differential mode, $-1mV < V_{IN} < +1mV$			10		
Input Common-Mode Range	V_{CM}	Guaranteed by CMRR test		$V_{SS} - 0.1$		$V_{DD} + 0.1$	V
Common-Mode Rejection Ratio	CMRR	$-0.1V < V_{CM} < V_{DD} + 0.1V$, $V_{DD} = 5.5V$		70	80		dB
Power-Supply Rejection Ratio	PSRR	$1.8V < V_{DD} < 5.5V$		65	85		dB
Open-Loop Gain	A_{VOL}	$25mV < V_{OUT} < V_{DD} - 25mV$, $R_L = 100k\Omega$, $V_{DD} = 5.5V$		95	120		dB
		$100mV < V_{OUT} < V_{DD} - 100mV$, $R_L = 5k\Omega$, $V_{DD} = 5.5V$		95	110		
Output-Voltage-Swing High	V_{OH}	$V_{DD} - V_{OUT}$	$R_L = 100k\Omega$		2.5	5	mV
			$R_L = 5k\Omega$		50	70	
			$R_L = 1k\Omega$		250		
Output-Voltage-Swing Low	V_{OL}	$V_{OUT} - V_{SS}$	$R_L = 100k\Omega$		2.5	5	mV
			$R_L = 5k\Omega$		50	70	
			$R_L = 1k\Omega$		250		
Channel-to-Channel Isolation	$CHISO$	Specified at DC, MAX9916/MAX9917			100		dB
Output Short-Circuit Current	$I_{OUT(SC)}$				± 15		mA

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ELECTRICAL CHARACTERISTICS (continued)

(V_{DD} = 1.8V to 5.5V, V_{SS} = 0V, V_{CM} = 0V, V_{OUT} = V_{DD} / 2, R_L = ∞ connected to V_{DD} / 2, \bar{SHDN}_- = V_{DD} , T_A = +25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
SHDN_ Logic Low	V _{IL}	V_{DD} = 1.8V to 3.6V, MAX9915/MAX9917			0.4		V
		V_{DD} = 3.6V to 5.5V, MAX9915/MAX9917			0.8		
SHDN_ Logic High	V _{IH}	V_{DD} = 1.8V to 3.6V, MAX9915/MAX9917		1.4			V
		V_{DD} = 3.6V to 5.5V, MAX9915/MAX9917		2			
SHDN_ Input Bias Current	I _{IL}	\bar{SHDN}_- = V_{SS} , MAX9915/MAX9917 (Note 2)			1		nA
	I _{IH}	\bar{SHDN}_- = V_{DD} , MAX9915/MAX9917			500		
Output Leakage in Shutdown	I _{OUT(SHDN_-)}	\bar{SHDN}_- = V_{SS} , V_{OUT} = 0V to V_{DD} , MAX9915/MAX9917		1	500		nA
Gain-Bandwidth Product				1			MHz
Phase Margin		C _L = 15pF		45			degrees
Gain Margin		C _L = 15pF		10			dB
Slew Rate				0.5			V/µs
Capacitive-Load Stability (See the <i>Driving Capacitive Loads</i> Section)	C _{LOAD}	No sustained oscillations	A _v = 1V/V	30			pF
			A _v = 10V/V	100			
			R _L = 5kΩ, A _v = 1V/V	100			
			R _{ISO} = 1kΩ, A _v = 1V/V	100			
Input Voltage-Noise Density		f = 1kHz		160			nV/√Hz
Input Current-Noise Density		f = 1kHz		0.001			pA/√Hz
Settling Time		To 0.1%, V_{OUT} = 2V step, A _v = -1V/V		3.5			µs
Delay Time to Shutdown	t _{SH}	I _{DD} = 5% of normal operation, V_{DD} = 5.5V, $V_{\bar{SHDN}_-}$ = 5.5V to 0 step		2			µs
Delay Time to Enable	t _{EN}	V_{OUT} = 2.7V, V_{OUT} settles to 0.1%, V_{DD} = 5.5V, $V_{\bar{SHDN}_-}$ = 0 to 5.5V step		10			µs
Power-Up Time		V_{DD} = 0 to 5.5V step		2			µs

ELECTRICAL CHARACTERISTICS

(V_{DD} = 1.8V to 5.5V, V_{SS} = 0V, V_{CM} = 0V, V_{OUT} = V_{DD} / 2, R_L = ∞ connected to V_{DD} / 2, \bar{SHDN}_- = V_{DD} , T_A = -40°C to +85°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS	
Supply Voltage Range	V _{DD}	Guaranteed by PSRR test		1.8	5.5		V	
Supply Current	I _{DD}	MAX9914/MAX9915	V _{DD} = 5.5V		29		µA	
					60			
Shutdown Supply Current	I _{DD(SHDN_-)}	\bar{SHDN}_- = GND, MAX9915/MAX9917			1		µA	
Input Offset Voltage	V _{OS}				±3		mV	
Input-Offset-Voltage Temperature Coefficient	T _{CVOS}				±5		µV/°C	

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ELECTRICAL CHARACTERISTICS (continued)

(V_{DD} = 1.8V to 5.5V, V_{SS} = 0V, V_{CM} = 0V, V_{OUT} = V_{DD} / 2, R_L = ∞ connected to V_{DD} / 2, SHDN₋ = V_{DD}, T_A = -40°C to +85°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Bias Current	I _B				± 30	pA
Input Offset Current	I _{OS}				± 20	pA
Input Common-Mode Range	V _{CM}	Guaranteed by CMRR test	V _{SS} - 0.05	V _{DD} + 0.05		V
Common-Mode Rejection Ratio	CMRR	-0.05V < V _{CM} < V _{DD} + 0.05V, V _{DD} = 5.5V	60			dB
Power-Supply Rejection Ratio	PSRR	1.8V < V _{DD} < 5.5V	60			dB
Open-Loop Gain	AvOL	25mV < V _{OUT} < V _{DD} - 25mV, R _L = 100k Ω , V _{DD} = 5.5V	85			dB
		150mV < V _{OUT} < V _{DD} - 150mV, R _L = 5k Ω , V _{DD} = 5.5V	85			
Output-Voltage-Swing High	V _{OH}	V _{DD} - V _{OUT}	R _L = 100k Ω	6		mV
			R _L = 5k Ω	90		
Output-Voltage-Swing Low	V _{OL}	V _{OUT} - V _{SS}	R _L = 100k Ω	5		mV
			R _L = 5k Ω	90		
SHDN ₋ Logic Low	V _{IL}	V _{DD} = 1.8V to 3.6V, MAX9915/MAX9917		0.4		V
		V _{DD} = 3.6V to 5.5V, MAX9915/MAX9917		0.8		
SHDN ₋ Logic High	V _{IH}	V _{DD} = 1.8V to 3.6V, MAX9915/MAX9917		1.4		V
		V _{DD} = 3.6V to 5.5V, MAX9915/MAX9917		2		
SHDN ₋ Input Bias Current	I _{IL}	SHDN ₋ = V _{SS} , MAX9915/MAX9917		5	nA	
	I _{IH}	SHDN ₋ = V _{DD} , MAX9915/MAX9917		1000	nA	
Output Leakage in Shutdown	I _{OUT(SHDN_-)}	SHDN ₋ = V _{SS} , V _{OUT} = 0V to V _{DD} , MAX9915/MAX9917		1000	nA	

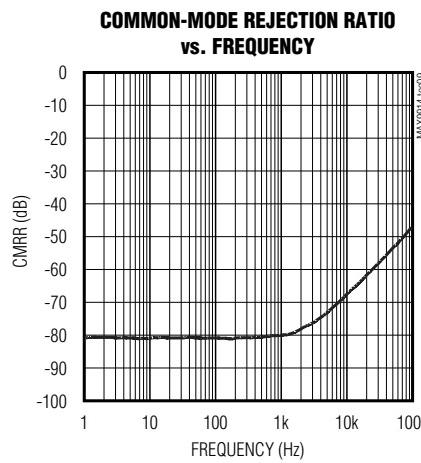
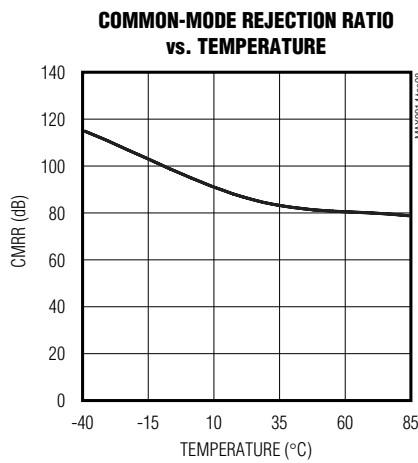
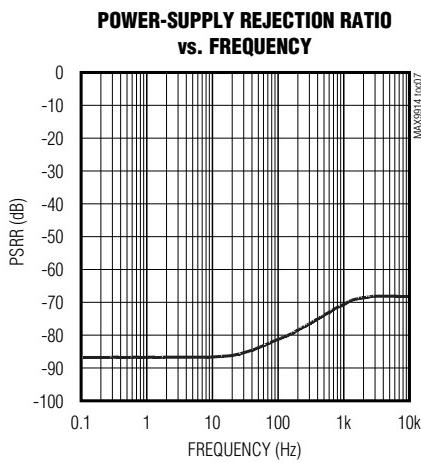
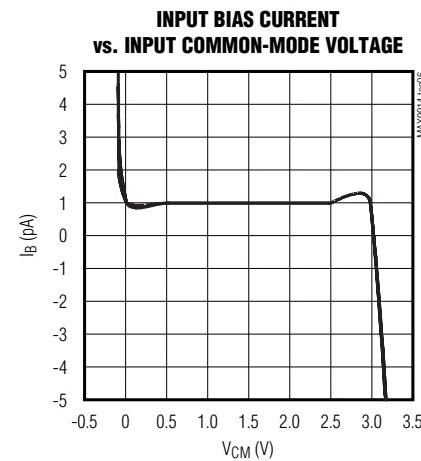
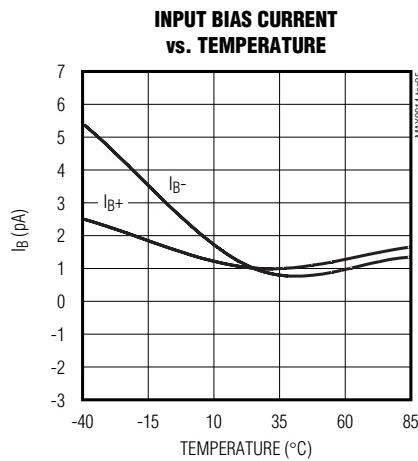
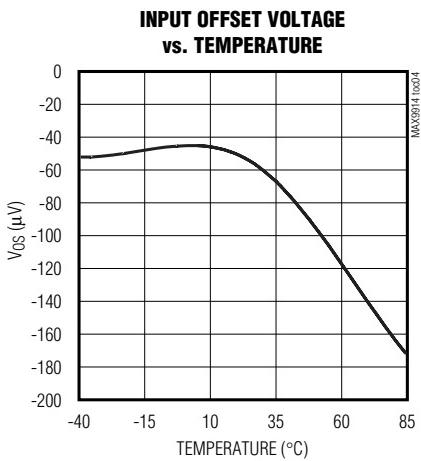
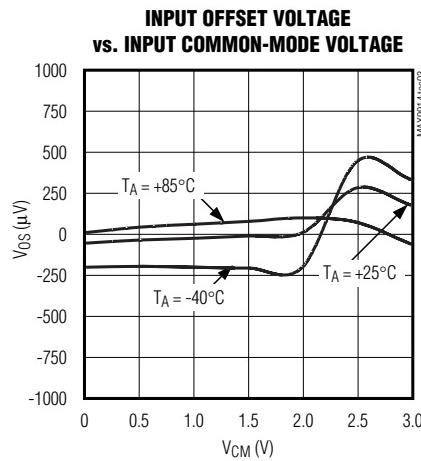
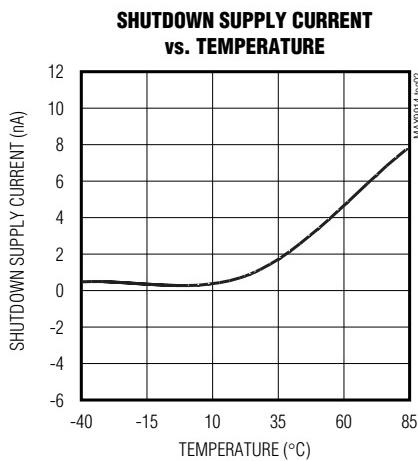
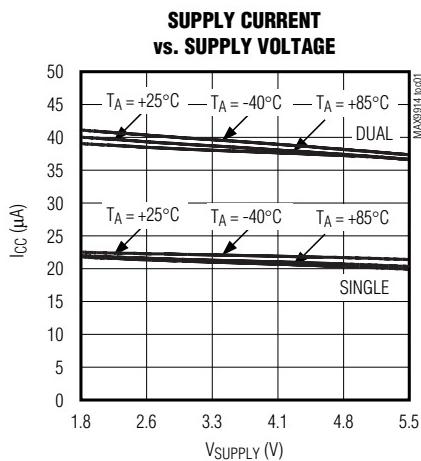
Note 1: Specifications are 100% tested at T_A = +25°C (exceptions noted). All temperature limits are guaranteed by design.

Note 2: Guaranteed by design, not production tested

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Typical Operating Characteristics

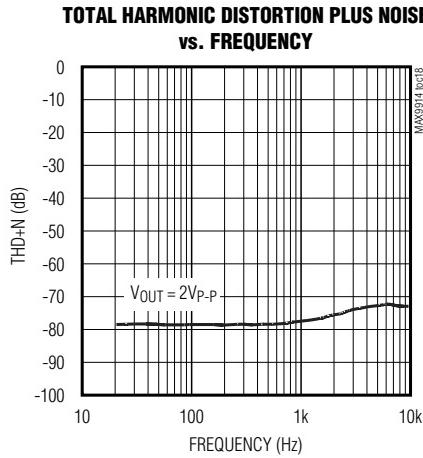
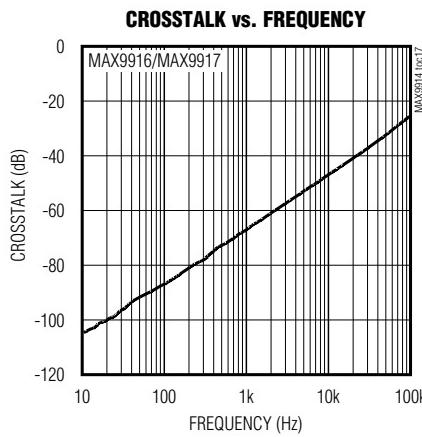
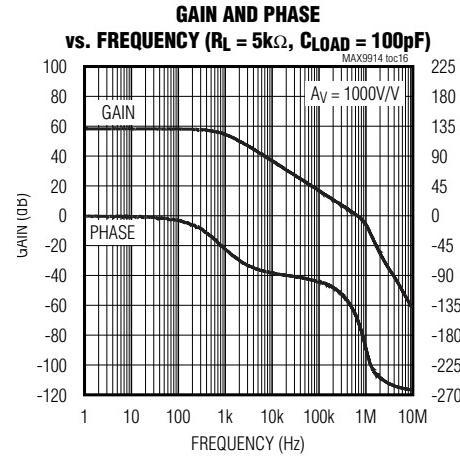
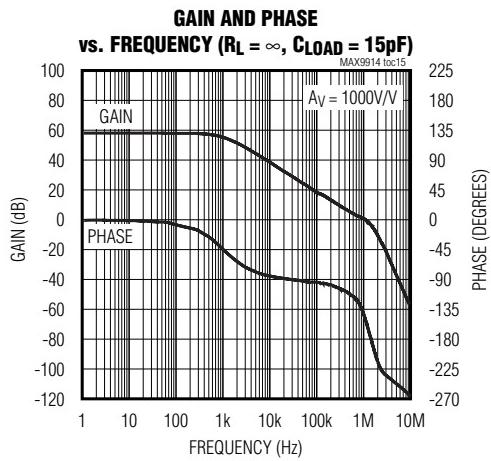
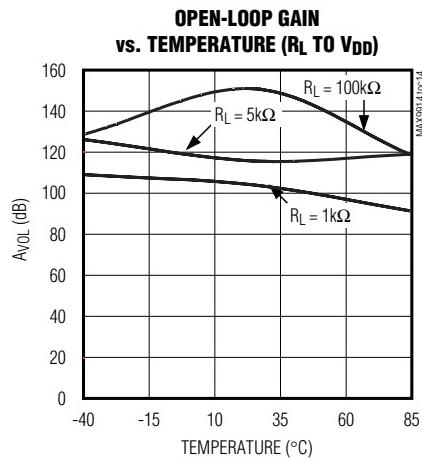
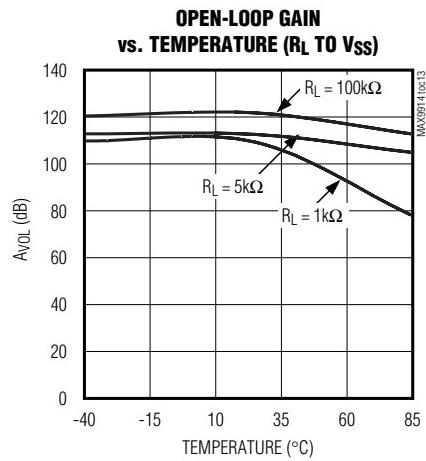
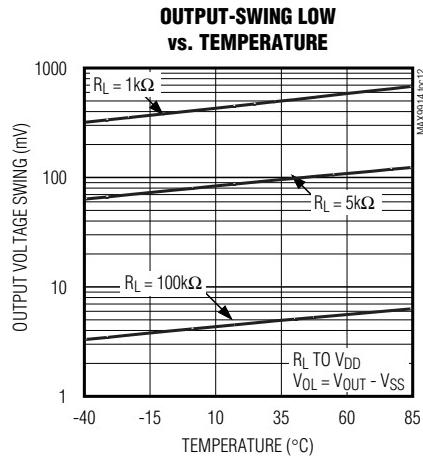
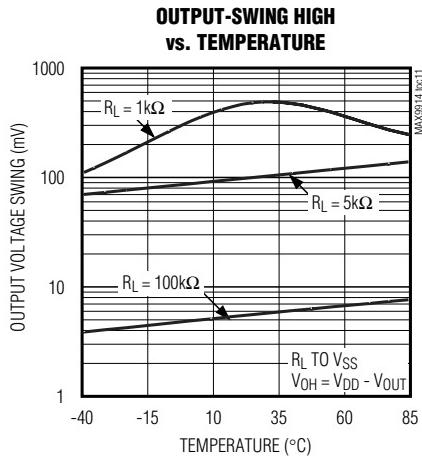
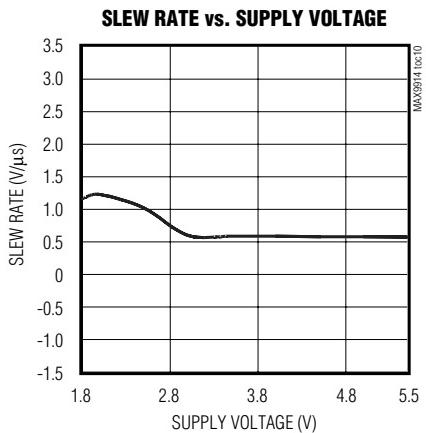
($V_{DD} = 3V$, $V_{SS} = V_{CM} = 0V$, R_L to $V_{DD}/2$, $T_A = +25^\circ C$, unless otherwise noted.)



1MHz, 20 μ A, Rail-to-Rail I/O Op Amps with Shutdown

Typical Operating Characteristics (continued)

(V_{DD} = 3V, V_{SS} = V_{CVM} = 0V, R_L to V_{DD} / 2, TA = +25°C, unless otherwise noted.)

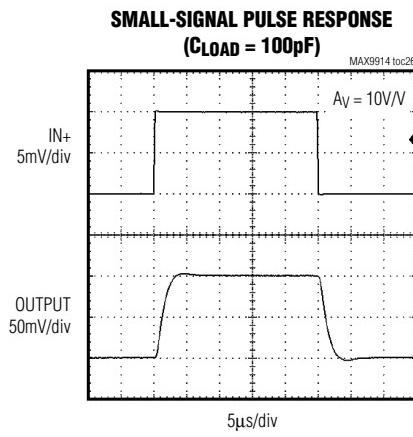
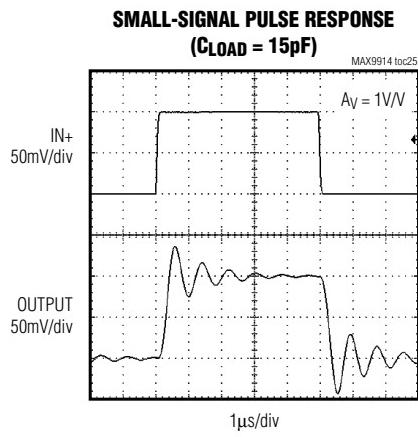
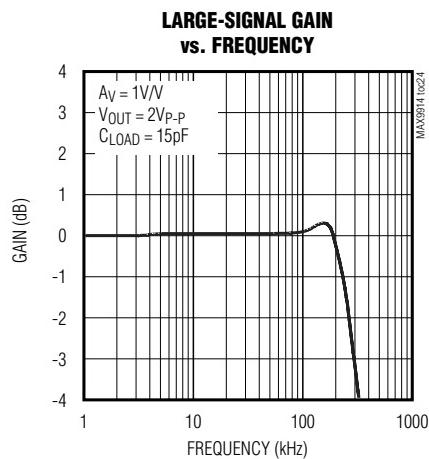
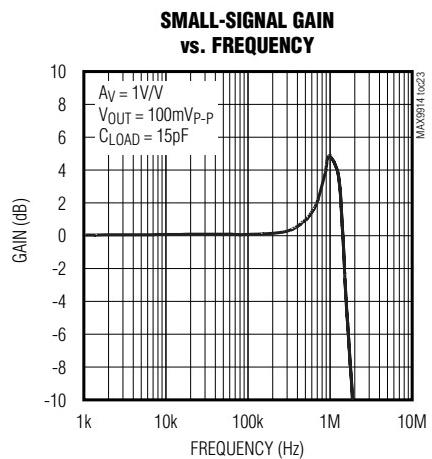
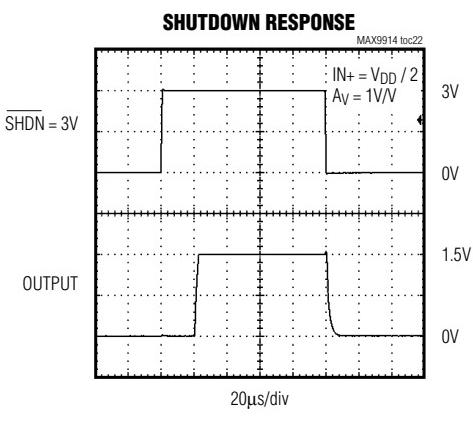
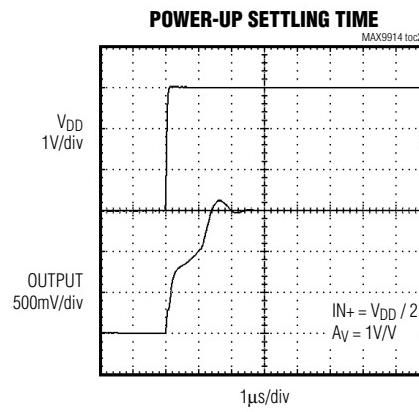
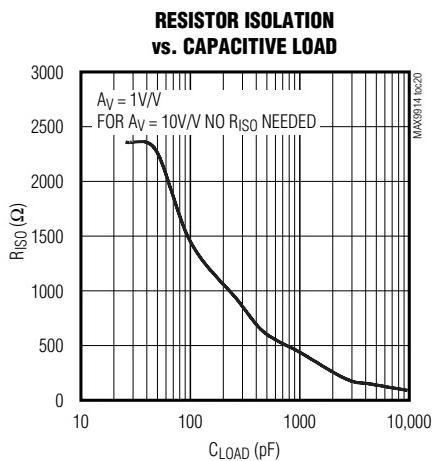
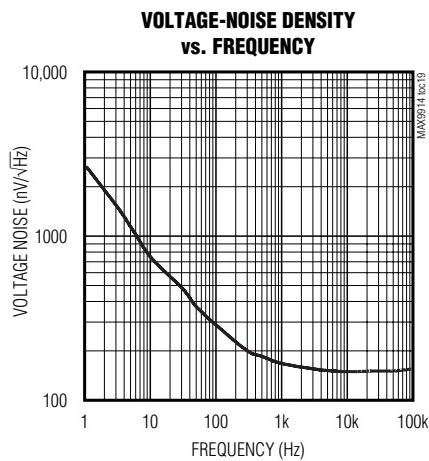


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Typical Operating Characteristics (continued)

(V_{DD} = 3V, V_{SS} = V_{CVM} = 0V, R_L to V_{DD} / 2, T_A = +25°C, unless otherwise noted.)

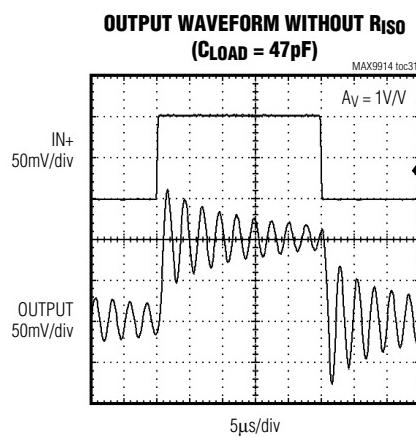
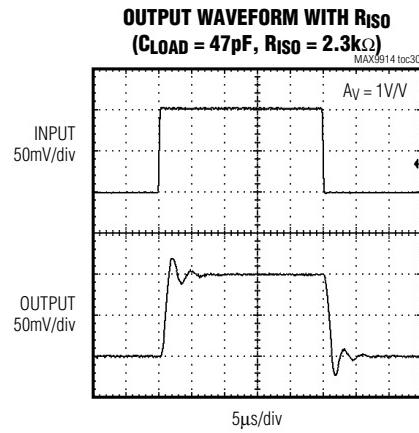
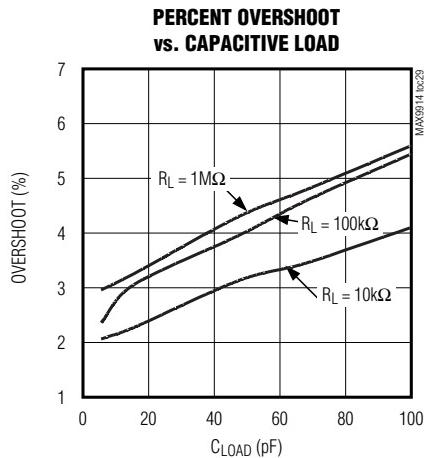
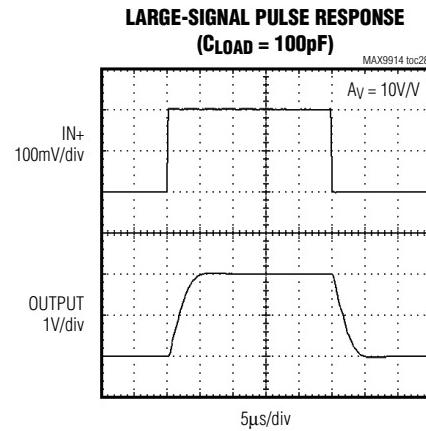
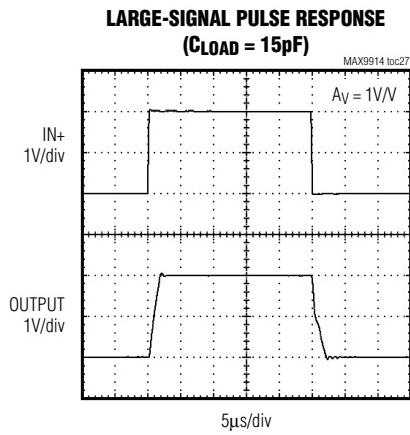
MAX9914-MAX9917



1MHz, 20 μ A, Rail-to-Rail I/O Op Amps with Shutdown

Typical Operating Characteristics (continued)

(V_{DD} = 3V, V_{SS} = V_{CVM} = 0V, R_L to V_{DD} / 2, T_A = +25°C, unless otherwise noted.)



1MHz, 20 μ A, Rail-to-Rail I/O Op Amps with Shutdown

Pin Description

PIN				NAME	FUNCTION
MAX9914	MAX9915	MAX9916	MAX9917		
1	1	—	—	IN+	Noninverting Amplifier Input
2	2	4	4	Vss	Negative Supply Voltage
3	3	—	—	IN-	Inverting Amplifier Input
4	4	—	—	OUT	Amplifier Output
5	6	8	10	VDD	Positive Supply Voltage
—	5	—	—	SHDN	Shutdown
—	—	1	1	OUTA	Amplifier Output Channel A
—	—	2	2	INA-	Inverting Amplifier Input Channel A
—	—	3	3	INA+	Noninverting Amplifier Input Channel A
—	—	—	5	SHDNA	Shutdown Channel A
—	—	—	6	SHDNB	Shutdown Channel B
—	—	5	7	INB+	Noninverting Amplifier Input Channel B
—	—	6	8	INB-	Inverting Amplifier Input Channel B
—	—	7	9	OUTB	Amplifier Output Channel B

Detailed Description

Featuring a maximized ratio of gain bandwidth to supply current, low operating supply voltage, low input bias current, and rail-to-rail inputs and outputs, the MAX9914–MAX9917 are an excellent choice for precision or general-purpose low-current, low-voltage, battery-powered applications. These CMOS devices consume an ultra-low 20 μ A (typ) supply current and a 200 μ V (typ) offset voltage. For additional power conservation, the MAX9914/MAX9917 feature a low-power shutdown mode that reduces supply current to 1nA (typ), and puts the amplifiers' output in a high-impedance state. These devices are unity-gain stable with a 1MHz gain-bandwidth product driving capacitive loads up to 30pF. The capacitive load can be increased to 100pF when the amplifier is configured for a 10V/V gain.

Rail-to-Rail Inputs and Outputs

The MAX9914–MAX9917 amplifiers all have a parallel-connected n- and p-channel differential input stage that allows an input common-mode voltage range that extends 100mV beyond the positive and negative supply rails, with excellent common-mode rejection.

The MAX9914–MAX9917 are capable of driving the output to within 5mV of both supply rails with a 100k Ω load. These devices can drive a 5k Ω load with swings to within 60mV of the rails. Figure 1 shows no clipping at the output voltage swing of the MAX9914–MAX9917 configured as a unity-gain buffer powered from a single 3V supply.

Low Input Bias Current

The MAX9914–MAX9917 feature ultra-low 1pA (typ) input bias current. The variation in the input bias current is minimal with changes in the input voltage due to very high input impedance (in the order of 1G Ω).

Applications Information

Driving Capacitive Loads

The MAX9914–MAX9917 amplifiers are unity-gain stable for loads up to 30pF. However, the capacitive load can be increased to 100pF when the amplifier is configured for a minimum gain of 10V/V.

Applications that require greater capacitive drive capability should use an isolation resistor between the output and the capacitive load (Figure 2). Also, in unity-gain applications with relatively small R_L (about 5k Ω), the capacitive load can be increased up to 100pF.

MAX9914–MAX9917

1MHz, 20µA, Rail-to-Rail I/O Op Amps with Shutdown

Power-Supply Considerations

The MAX9914–MAX9917 are optimized for single 1.8V to 5.5V supply operation. A high amplifier power-supply rejection ratio of 85dB (typ) allows the devices to be powered directly from a battery, simplifying design and extending battery life.

Power-Up Settling Time

The MAX9914–MAX9917 typically require 2µs after power-up. Supply settling time depends on the supply voltage, the value of the bypass capacitor, the output impedance of the incoming supply, and any lead resistance or inductance between components. Op amp settling time depends primarily on the output voltage and is slew-rate limited. Figure 3 shows the MAX9914 in a noninverting voltage follower configuration with the input held at midsupply. The output settles in approximately 3.5µs for V_{DD} = 3V (see the *Typical Operating Characteristics* for the Power-Up Settling Time graph).

Shutdown Mode

The MAX9915 and MAX9917 feature active-low shutdown inputs. The MAX9915 and MAX9917 enter shutdown in 2µs (typ) and exit shutdown in 10µs (typ). The amplifiers' outputs are high impedance in shutdown mode. Drive SHDN low to enter shutdown. Drive SHDN high to enable the amplifier. The MAX9917 dual amplifier features separate shutdown inputs. Shut down both amplifiers for lowest quiescent current.

Power-Supply Bypassing and Layout

Bypass V_{DD} with a 0.1µF capacitor to ground as close to the pin as possible to minimize noise.

Good layout techniques optimize performance by decreasing the amount of stray capacitance and inductance to the op amp's inputs and outputs. Minimize stray capacitance and inductance, by placing external components close to the IC.

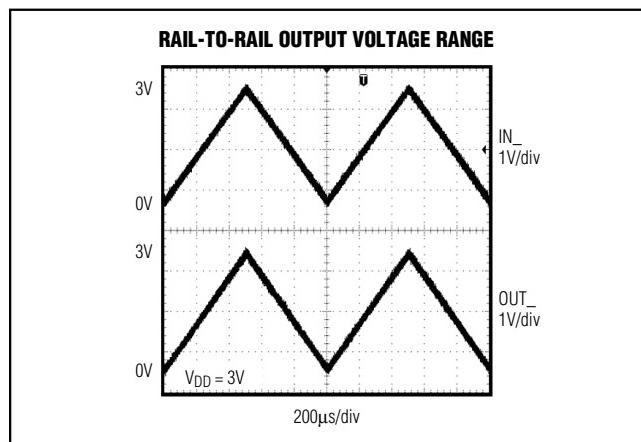


Figure 1. Rail-to-Rail Output Voltage Range

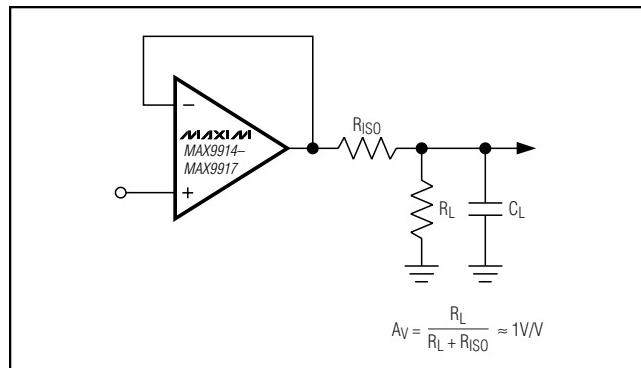


Figure 2. Using a Resistor to Isolate a Capacitive Load from the Op Amp

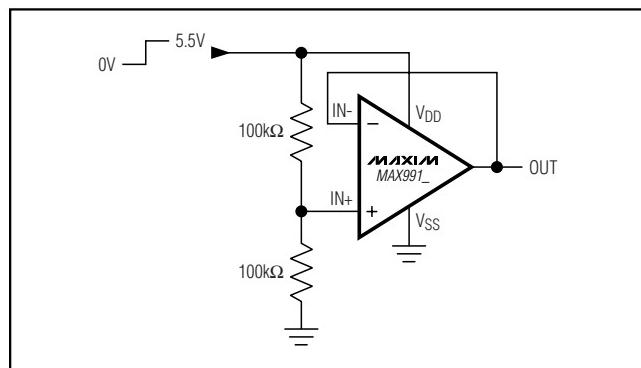
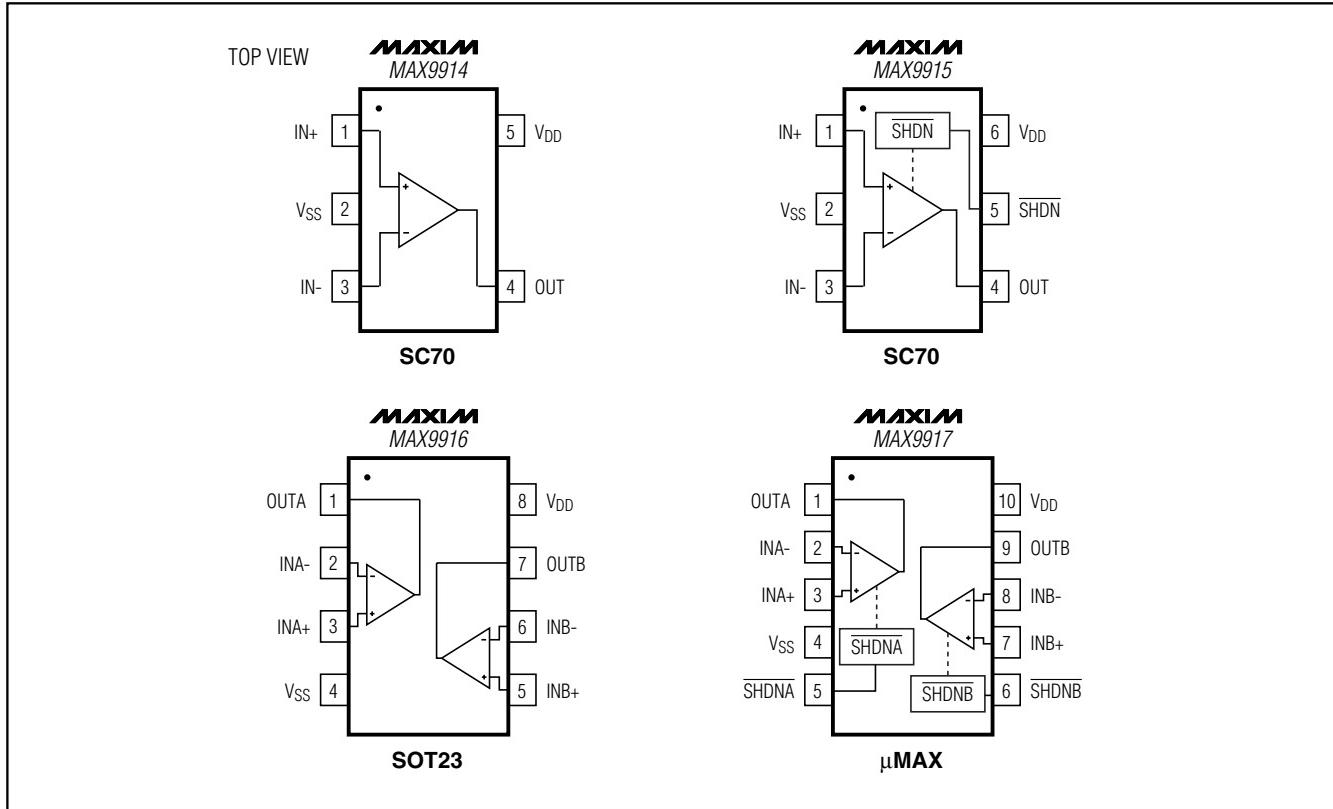


Figure 3. Power-Up Test Configuration

1MHz, 20 μ A, Rail-to-Rail I/O Op Amps with Shutdown

Pin Configurations



Chip Information

MAX9914 TRANSISTOR COUNT: 180

MAX9915 TRANSISTOR COUNT: 180

MAX9916 TRANSISTOR COUNT: 292

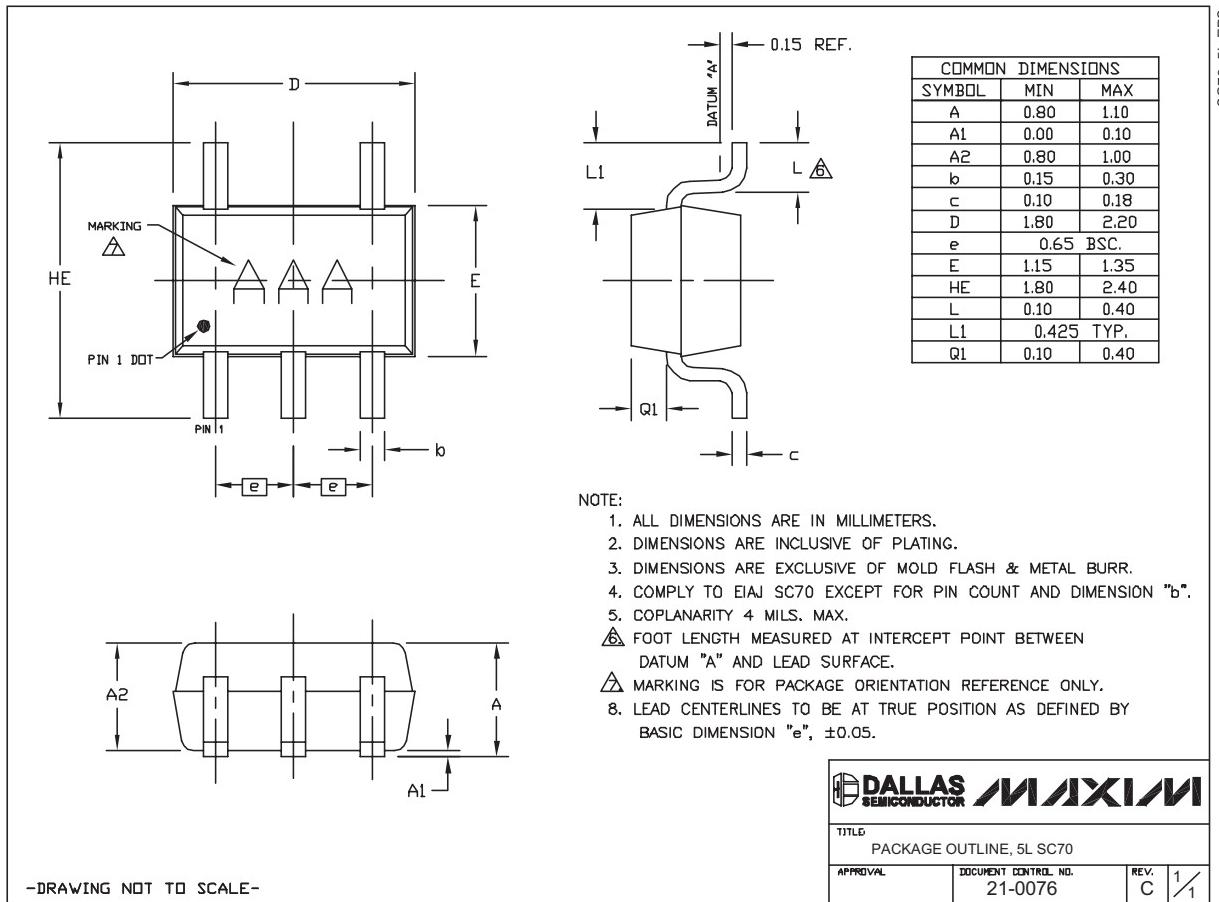
MAX9917 TRANSISTOR COUNT: 292

PROCESS: BiCMOS

1MHz, 20 μ A, Rail-to-Rail I/O Op Amps with Shutdown

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)

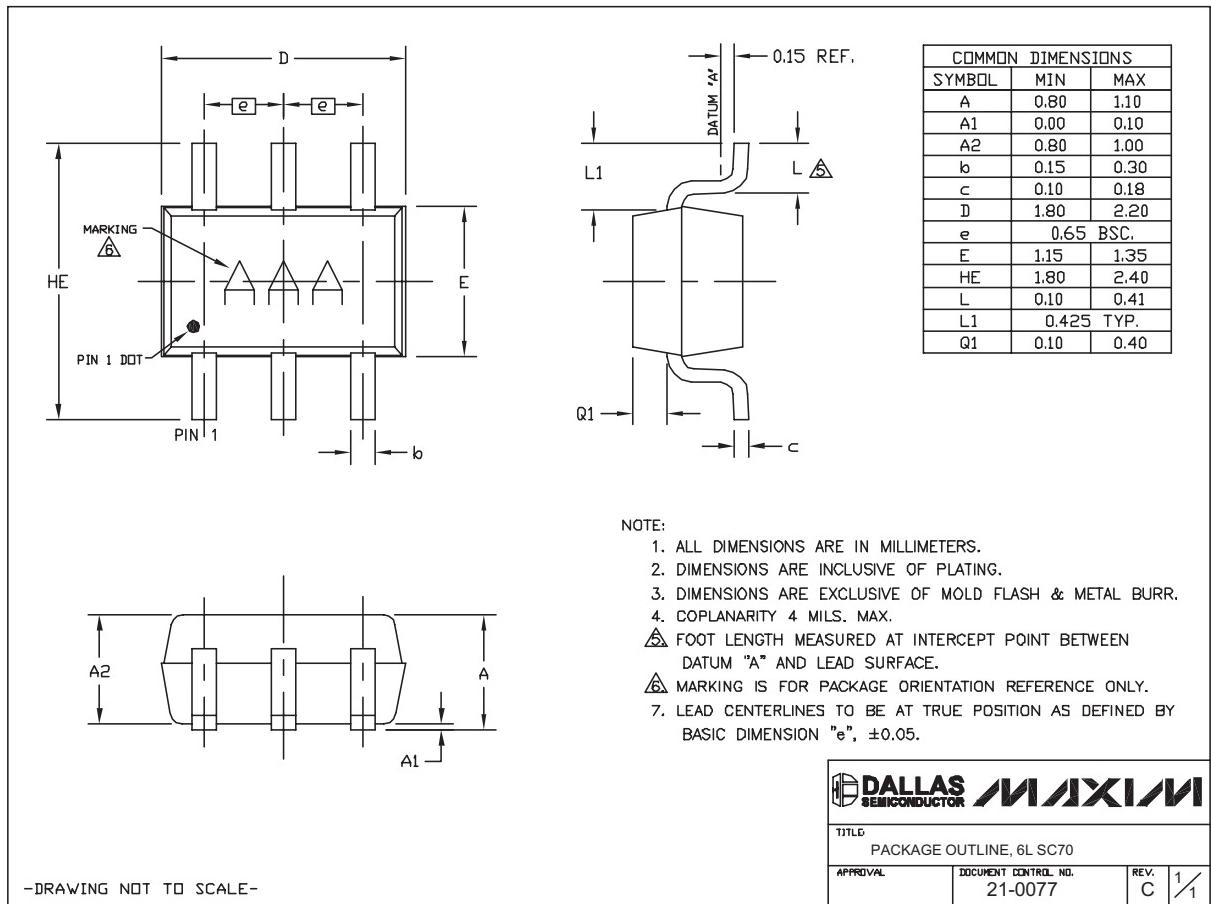


SC70_5LSC70

1MHz, 20µA, Rail-to-Rail I/O Op Amps with Shutdown

Package Information (continued)

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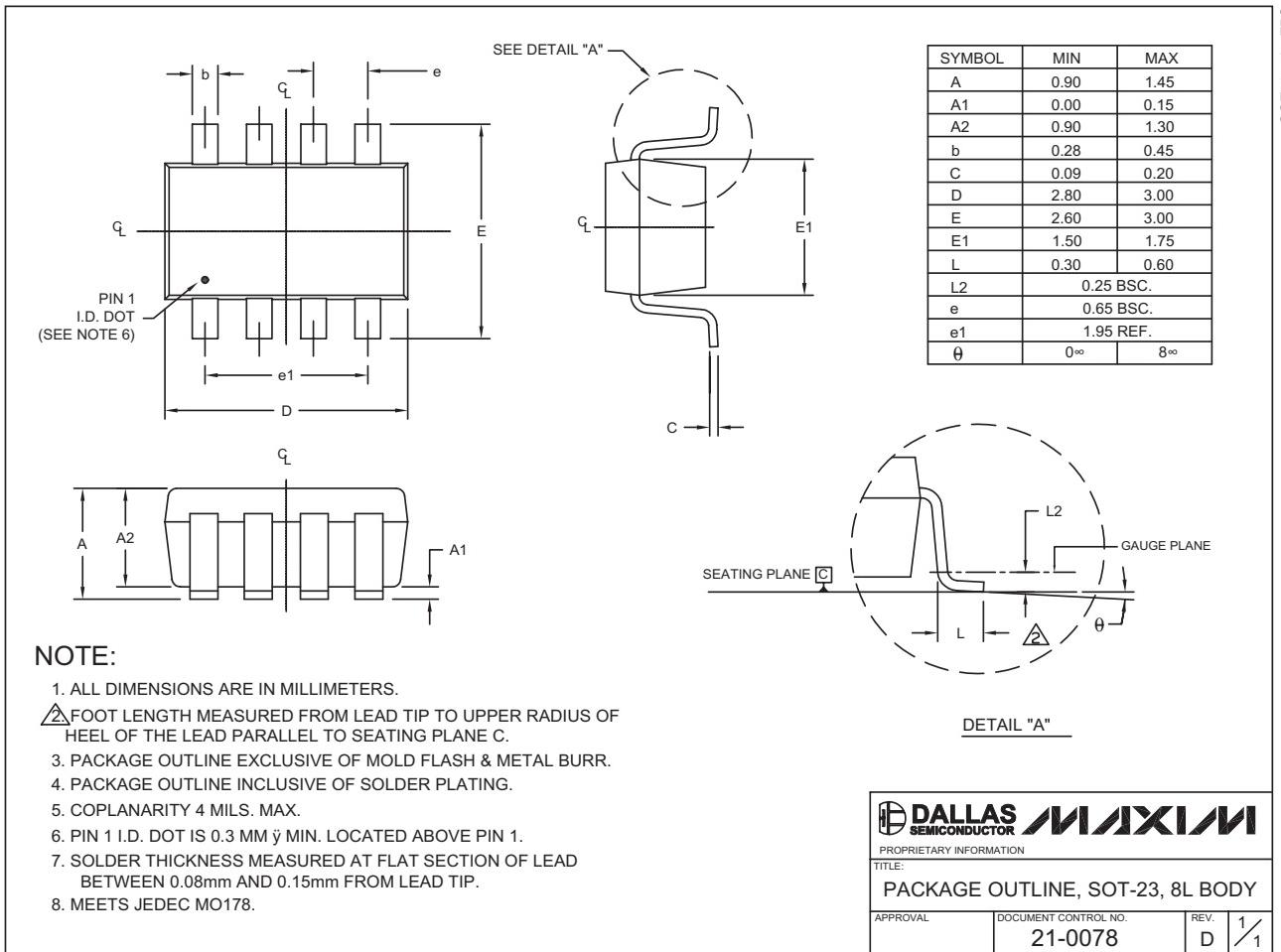
SC70_6L.EPS

MAX9914-MAX9917

1MHz, 20µA, Rail-to-Rail I/O Op Amps with Shutdown

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)



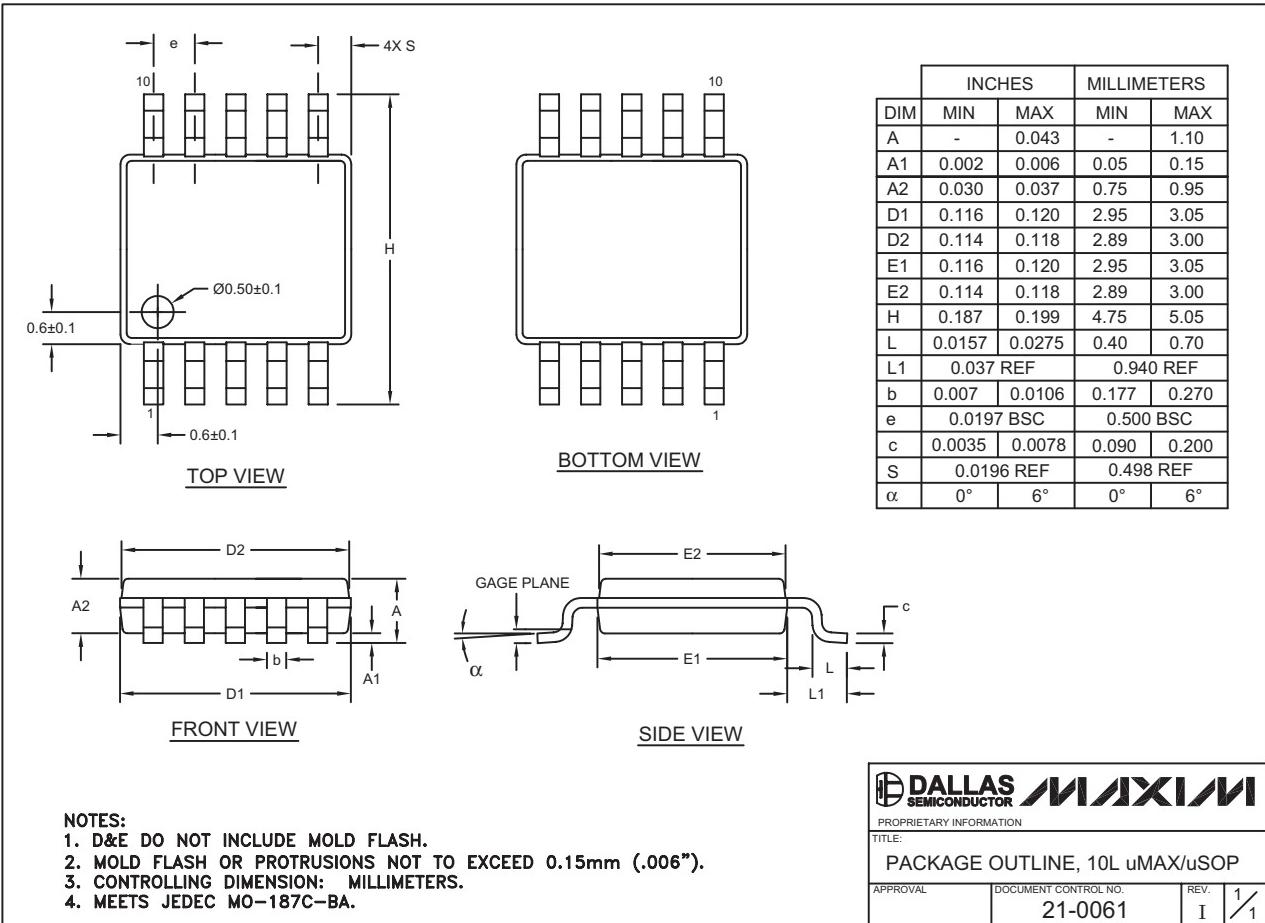
1MHz, 20 μ A, Rail-to-Rail I/O Op Amps with Shutdown

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)

MAX9914-MAX9917

10LUMAX.EPS



	DALLAS SEMICONDUCTOR	MAXIM
PROPRIETARY INFORMATION		
TITLE: PACKAGE OUTLINE, 10L uMAX/uSOP		
APPROVAL	DOCUMENT CONTROL NO. 21-0061	REV. I 1/1

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